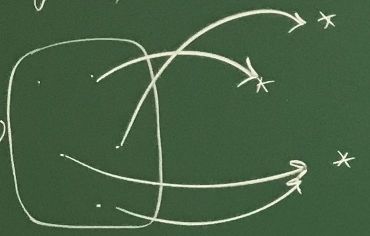
25 Feb 2020

Resource Allocation/Assignment/Control/Management

(Dynamic)

Resources



* discrete or continuous
* limited = valuable
* assignment = investment
  expectation of return
* each assignment results in a different return
* return: value of a KPI

radio resource ....

$\underbrace{\text{BW, power, antennas}}_{\text{rate}}$, $\underbrace{\text{computation}}_{\text{latency}}$, $\underbrace{\text{cache(memory)}}$

MEC: mobile edge computing

* consider BW: discrete problem

RB: resource block

PRB: physical RB

12 consecutive subcarriers

Each with 15 kHz of BW

$12 \times 15\text{kHz} = 180\text{kHz}$

(OFDM)

Ex: $B = 10\text{MHz}$

$\#$ of RBs $= \dfrac{10M}{200k} = 50$

$h(t) = \alpha\,\delta(t)$ ideal ch.

↳ ch gain $\quad \alpha \ll 1$

$\alpha: f(\underbrace{\text{time, freq}}_{\text{short-term stats}}, \underbrace{\text{location}}_{\text{long-term stats}})$

small-scale stats — large-scale stats

$PL = \dfrac{1}{\alpha^2}$

* snap-shot analysis
  time: frozen

t_1, t_2, ...

freeze → make decisions (assignments)

freeze

$t_2 - t_1 \sim$ the constant of the channel (coherence time)

Resource plane

RB M

f

RB 2

RB 1

0.5 ms $\quad t$

PRB: Smallest resource element that can be assigned by the LTE scheduler.

L UEs in one cell

BS $\xrightarrow{RB_i}$ $*UE_2$

$*UE_1$

$RB_i \to UE_2 : \alpha_{i2}$

$RB_i \to UE_1 : \alpha_{i1}$

$\alpha_{i1} \neq \alpha_{i2}$

BS $\xrightarrow{RB_1}$ $*UE_j$

$\xrightarrow{RB_2}$

$\alpha_{1j} \neq \alpha_{2j}$

* Assume there is no Power Control

$P_{RB} = \frac{P_{TX}}{M}$ → total TX power

LTE: 200 kHz

$R_{ij} = B_{RB} \log_2(1+SNR_{ij})$

i^{th} RB

j^{th} UE

$$SNR_{ij} = \frac{P_{RX}}{P_N} = \frac{\frac{P_{TX}}{M}\cdot \alpha_{ij}^2}{B_{RB} N_0}$$

$$M = \frac{B}{B_{RB}} \qquad = \alpha_{ij}^2 \left(\frac{P_{TX}/M}{B_{RB} N_0}\right)$$

B_{RB} → fixed

$$SE_{ij} = \frac{R_{ij}}{B_{RB}} = \log_2\left(1+\alpha_{ij}^2 \left[\frac{P_{TX}/M}{B_{RB}N_0}\right]\right)$$

utility: return

$\max_{\text{all possible assignment}}$ utility

subject to constraints

Optimization

math tool for RRM

↓

Machine Learning (ML)

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RB \ UE	1	2	…	L
1	2.7	0.3		6.7
2	1.9			
⋮				
M	3.2			

Downlink (DL) SE [b/s/Hz]

$$
\begin{array}{c|ccccc}
\text{RB}\backslash\text{UE} & 1 & 2 & & & L \\
\hline
1 & 0 & 1 & 0 & 0 & 0 \\
2 & 0 & 0 & \cdots & 1 & 0 \\
 & 1 & 0 & 0 & 0 & 0 \\
 & 0 & 0 & 0 & 0 & 1 \\
M & 1 & 0 & 0 & 0 & 0
\end{array}
$$

→ only one "1"

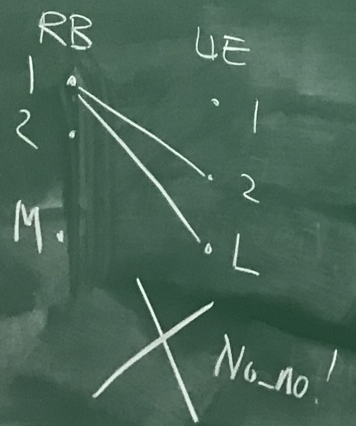
Examine SE

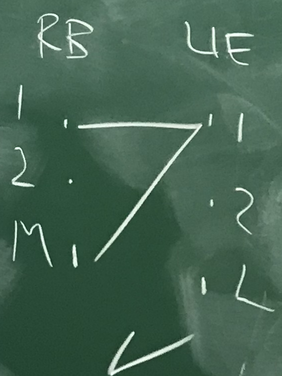
↓

Decide for I so that utility is optimized (max or min)

$$I_{ij} = \begin{cases} 1, & \text{if } RB_i \rightarrow UE_j \\ 0, & \text{if } RB_i \not\rightarrow UE_j \end{cases}$$

indicator function





utility: a user's rate (X)

sum rate of all users (✓)

s.t. "fairness"

$$\max_{\underline{I}} \sum_{j=1}^{L}\sum_{i=1}^{M} I_{ij}\, SE_{ij}$$

s.t. $\sum_{j=1}^{L} I_{ij} \in \{0,1\}, \forall i$ ≤ 1

$\sum_{j=1}^{L}\sum_{i=1}^{M} I_{ij} \in \{0,1,\dots,M\}$

$M = \frac{B}{B_{RB}}$

$P_{RB} = \frac{P_{TX}}{M}$

If M RBs, L UEs

How many $\underline{I}$s exist?

Ex: $L = 50$

$M = 200$

# of choices $\ll 2^{LM}$

$2^{LM} = 2^{10,000} = (2^{10})^{1000} \sim 10^{3000}$

# of particles in the universe $\sim 10^{80}$

NP-hard: non-polynomial in time

→ cannot be solved in a brute-force manner

RB \ UE	1	2	3
1	2	0	4
2	5	6	1
3	2	2	3
4	4	1	2
5	7	6	5
6	1	5	2

SE [b/s/Hz]

* Find $\underline{I}$ to maximize the sum rate

* max ΣR s.t. resource fair

* max ΣR s.t. $R_j = R_{UE}, \forall j$